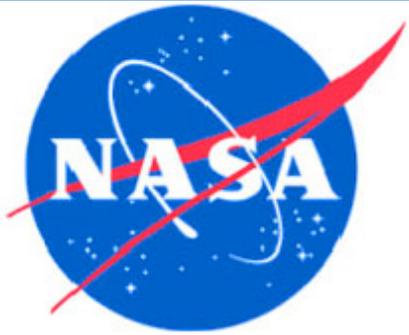


Influence of Precipitation on Regional Hydrology and Public Health: A Feasibility Study

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& Amy Carlson

UNIVERSITY OF NEW ENGLAND



Health and Air Quality Applications Program Review
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Newport, Rhode Island



Background

- Heavy rainfall events are more likely to lead to a decline in microbiological quality of inland and marine waters as a result of heavy runoff
- Pollutants travel downstream with river flow to the coastal ocean and adjacent waters, which results in **Reduced Water Quality Events (RWQEs)**.

Background

▣ Nationwide

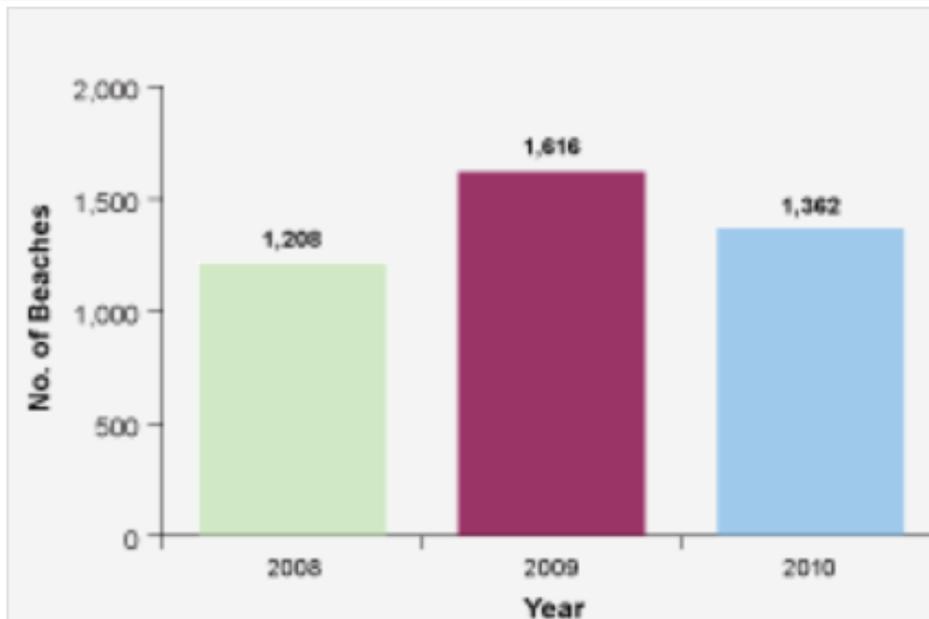


Figure 2: Number of beaches with notification actions from 2008 to 2010.

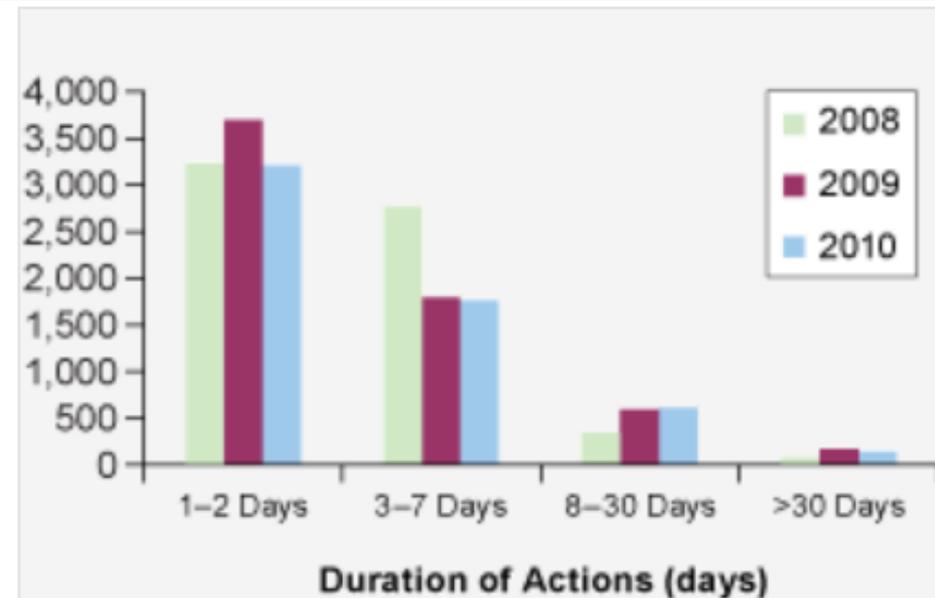


Figure 3: Duration of beach notification actions from 2008 to 2010.

Background

▣ Maine Beach Actions

Table 2. Beach notification actions, 2008–2010.

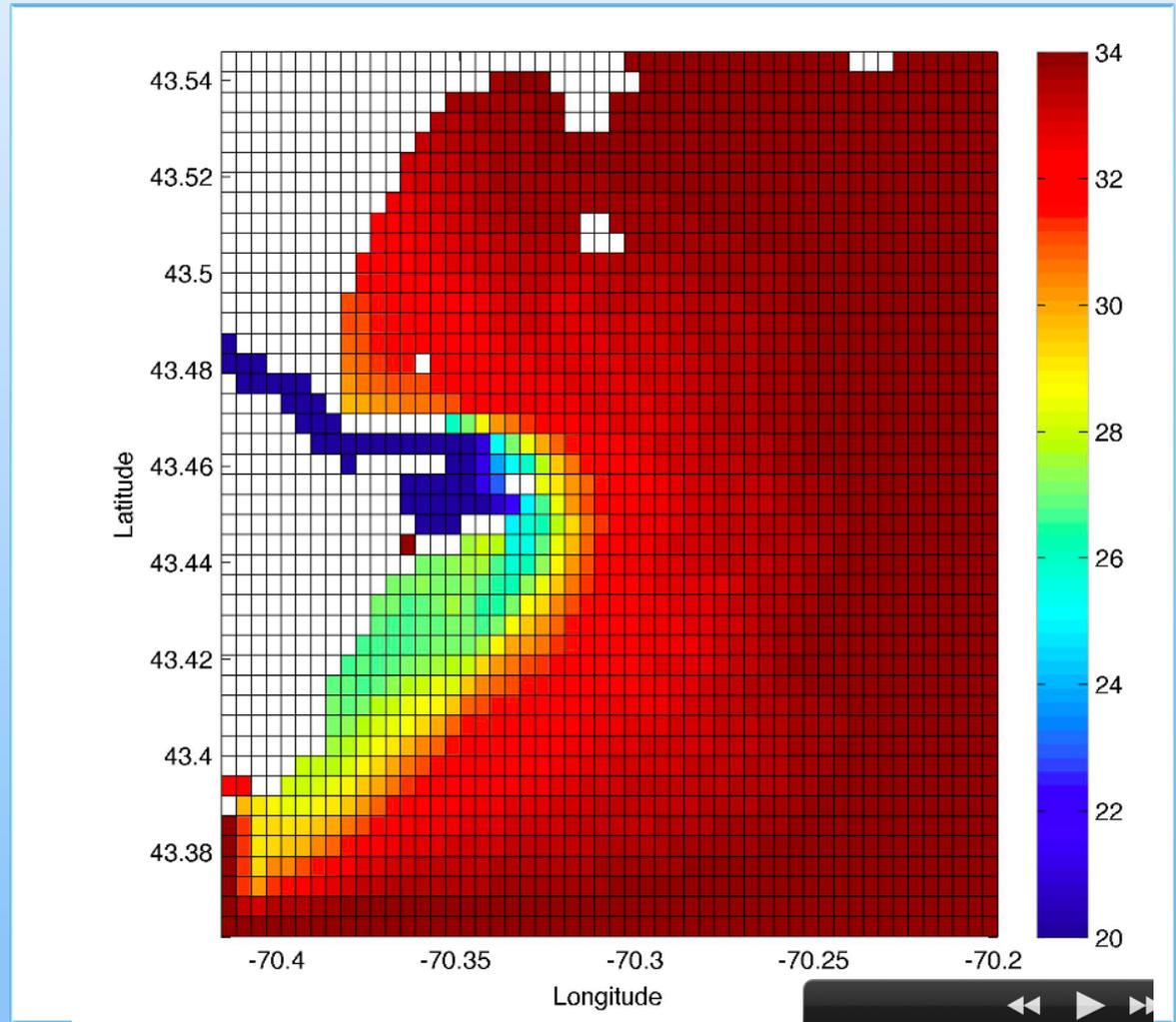
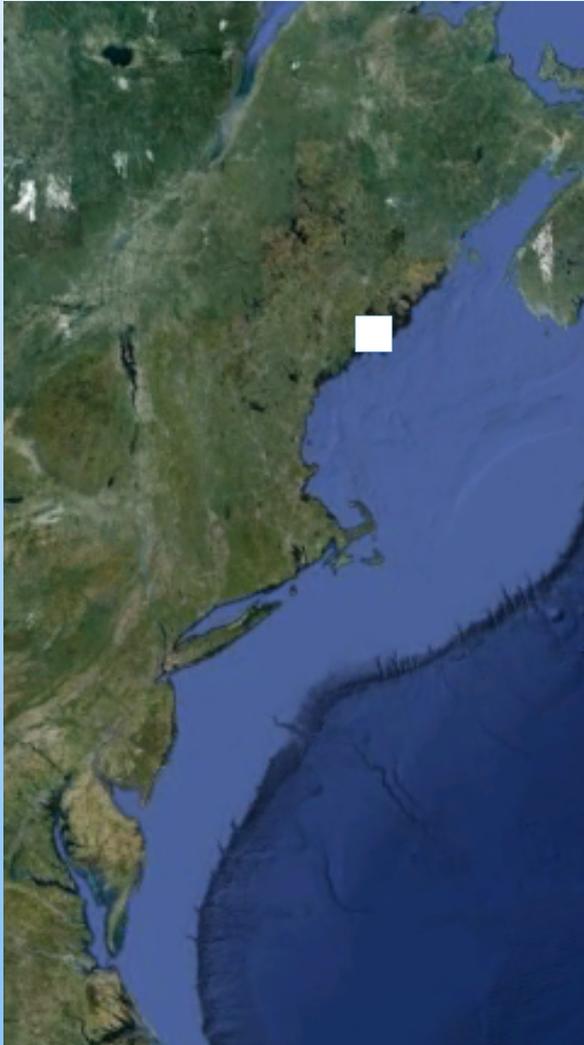
Year	2008	2009	2010
Number of monitored beaches	60	60	59
Number of beaches affected by notification actions	22	36	29
Percentage of beaches affected by notification actions	37%	60%	49%
Percentage of beach days affected by notification actions	3%	4%	4%

Background

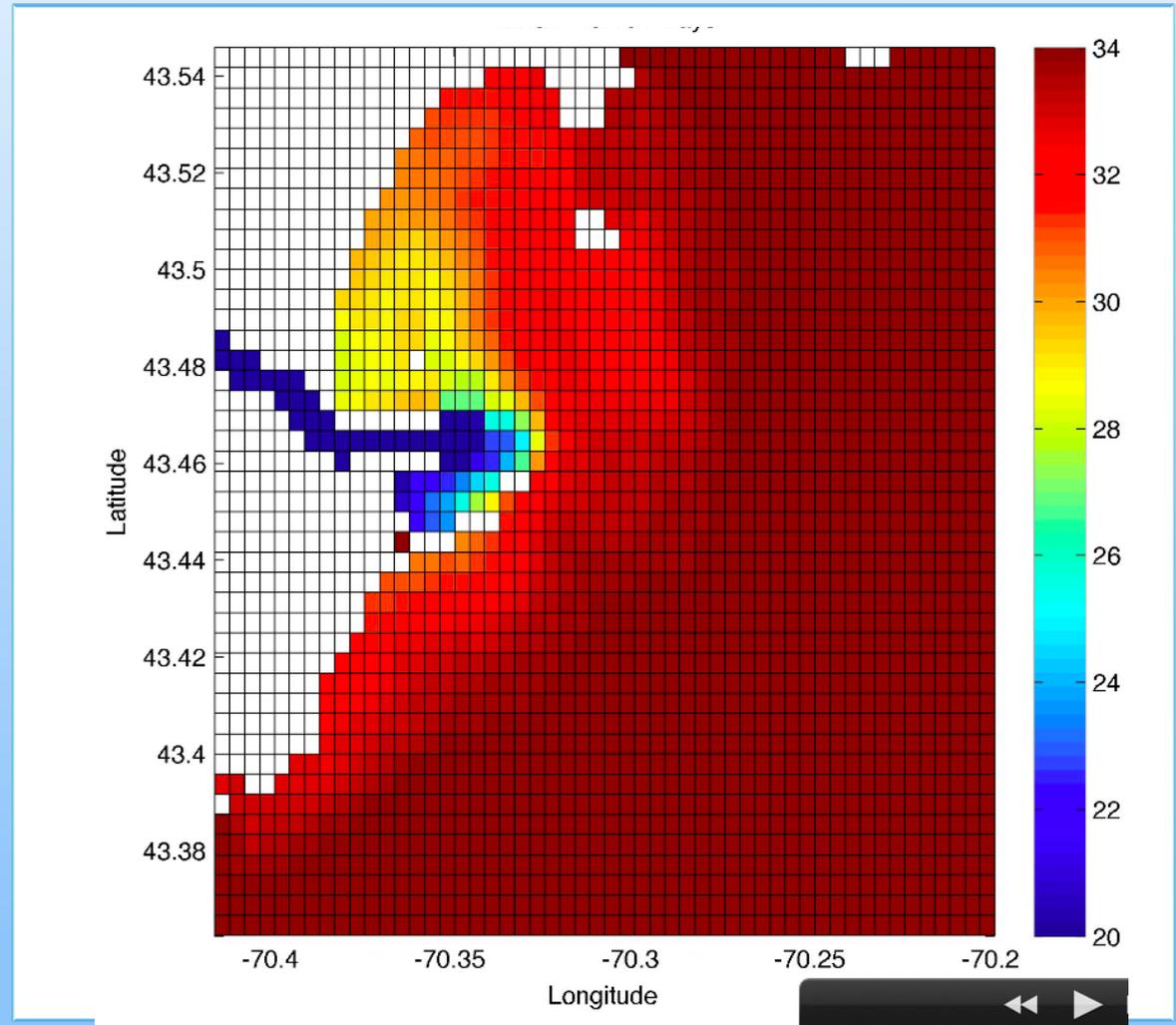
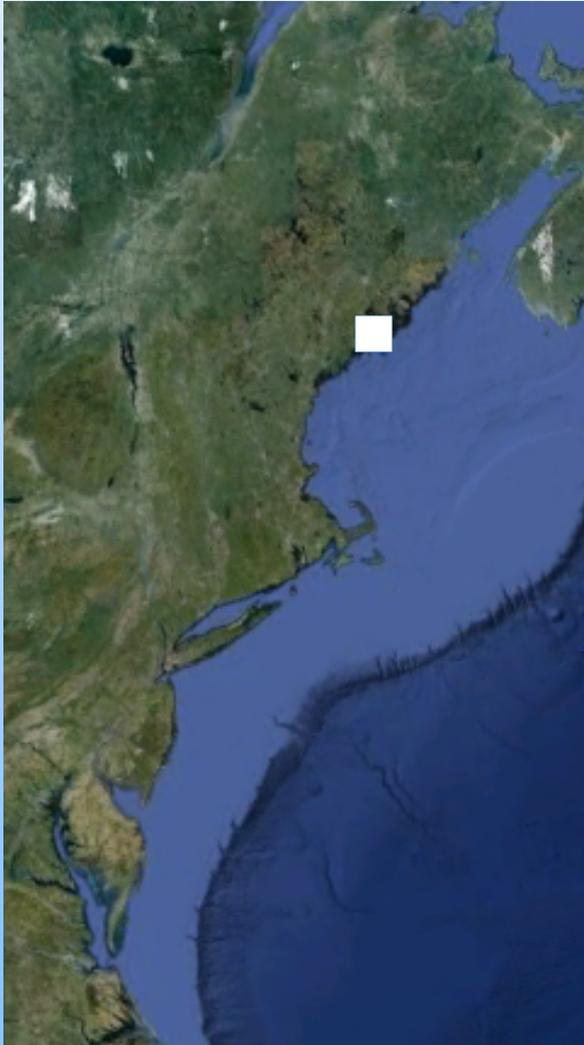
▣ Beach Actions in Maine 2010



Pollutants can travel within river plumes



Pollutants can travel within river plumes



Decision Making Activities

- **States need a low cost, rapid method for estimating water quality to protect human health.**
 - A number of states are unable to quickly test for harmful bacteria in coastal waters
 - States are unable to warn their citizens of harmful water quality.

Decision Making Activities

- Current Maine Department of Marine Resources management strategy
 - Each river is assigned a discharge that will result in a predicted RWQE.
 - When river discharge exceeds this value, shellfish beds and recreational areas are closed and testing of the region begins.

The Issue

- Resource managers need accurate predictions of RWQEs to protect local populations
- Current methods of forecasting unhealthy levels of contaminants such as coliform bacteria are unreliable
 - Result in too many false alarms
 - False alarms hurt local economies and fishermen
- Traditional microbiological techniques are too slow
 - *E. coli* testing takes 18 hours to complete, plus sampling time.

Collaborators

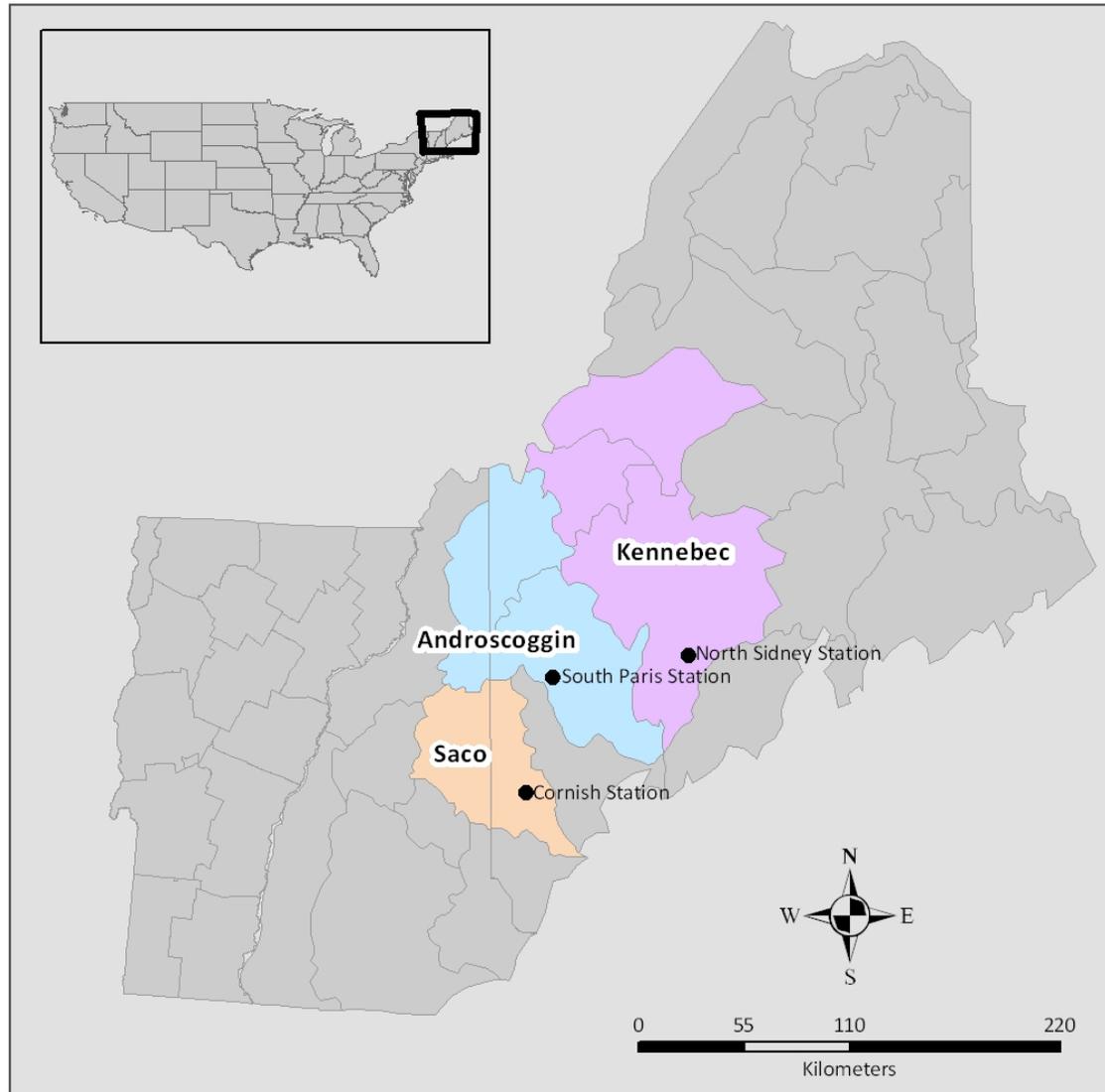
- Maine Department of Marine Resources
- Maine State Planning Office
- Saco River Corridor Commission
- 7 area K-12 schools

Data-gathering meeting in 2010 with Maine State Planning Office, Maine Department of Marine Resources, Maine Department of Transportation, and Maine Department of Inland Fisheries and Wildlife

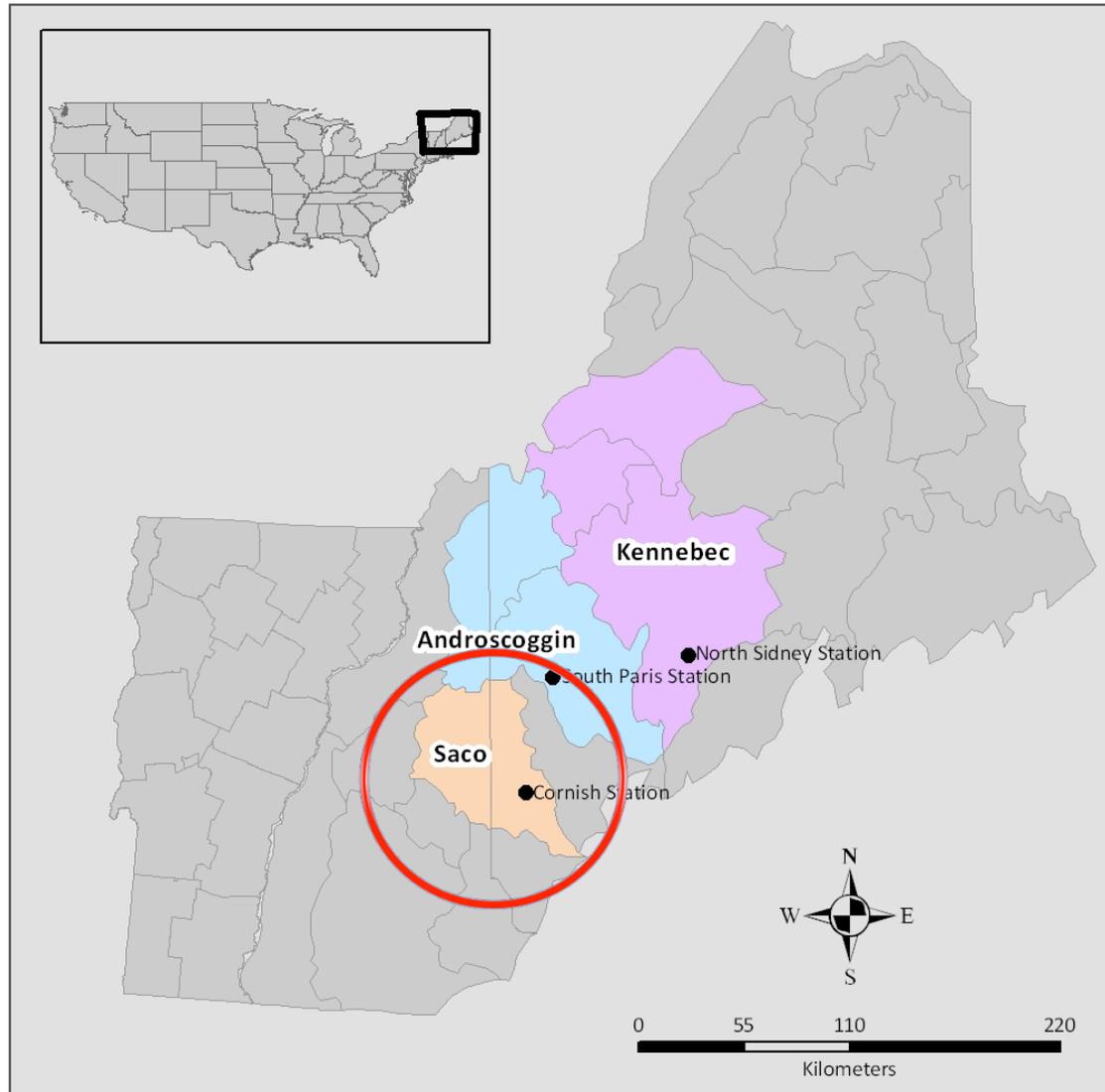
Objectives

- Develop a method to accurately predict when levels of contamination within coastal waters exceed statutory limits.
- Use readily available data to investigate those physical factors that affect water quality

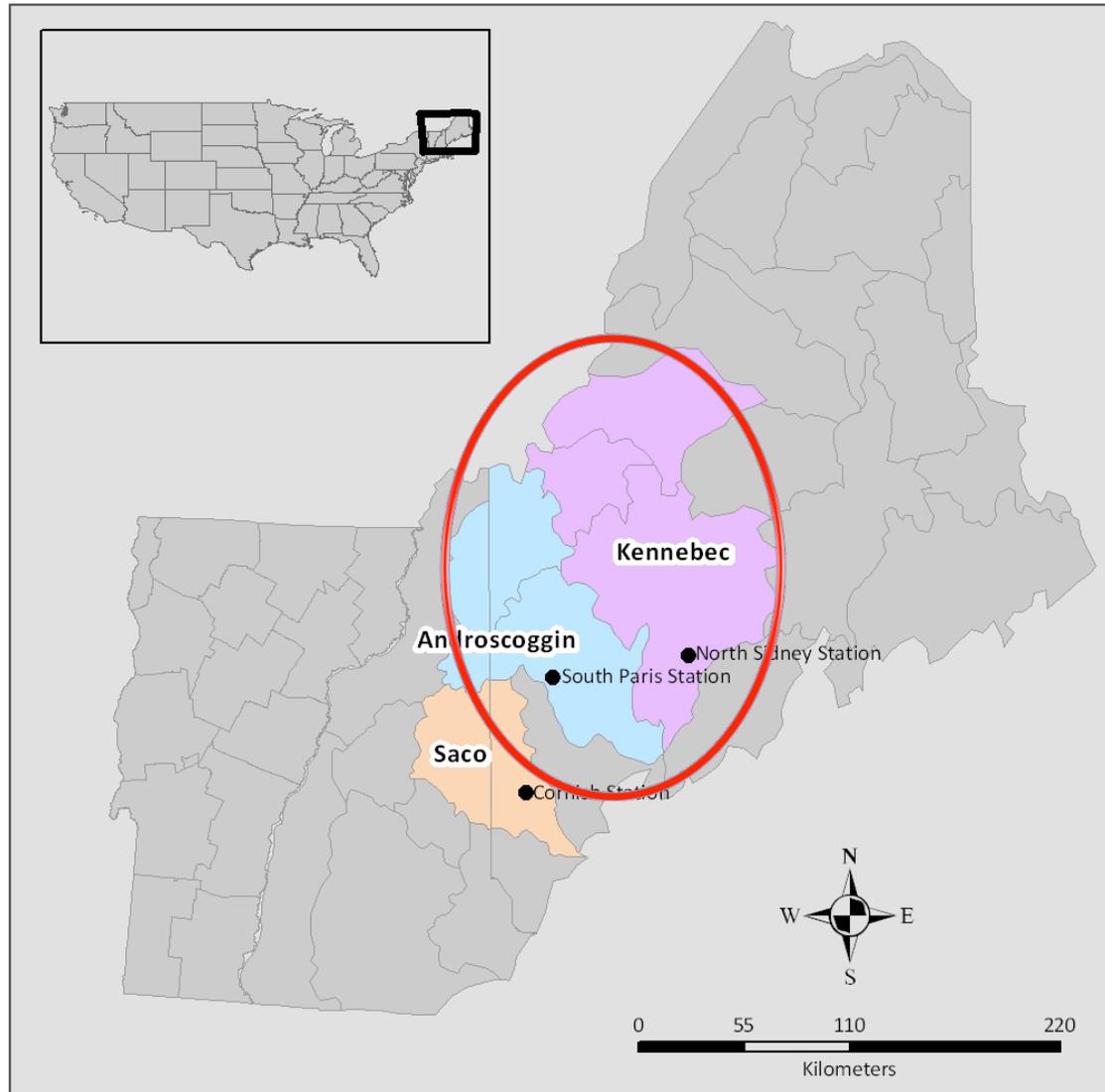
Test Case: Three watersheds in Maine



Test Case: Three watersheds in Maine



Test Case: Three watersheds in Maine



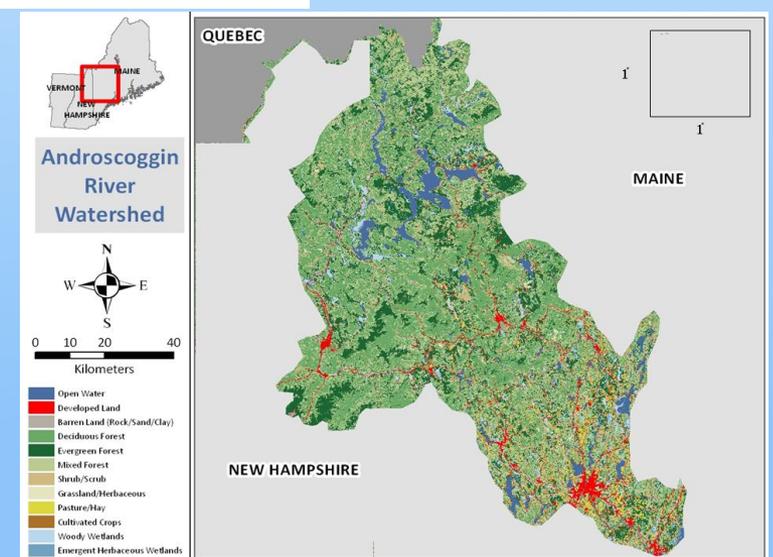
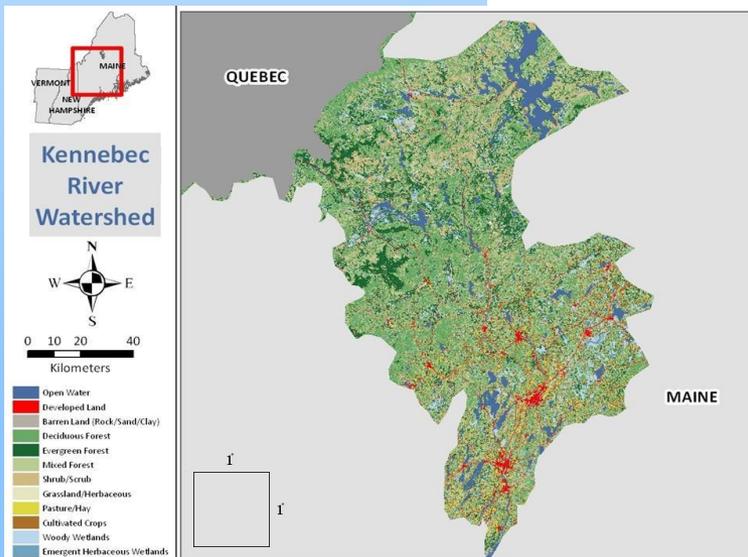
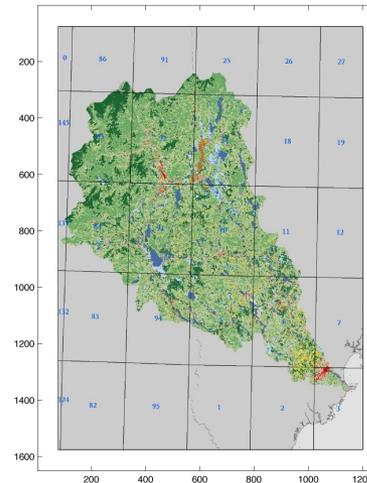
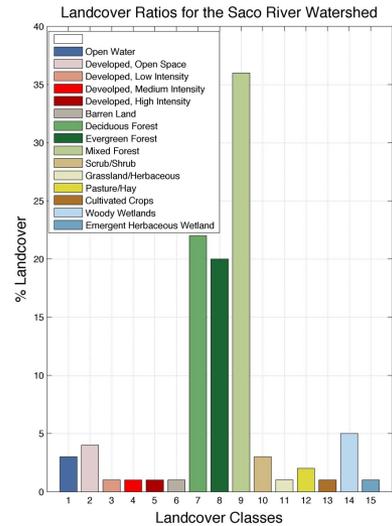
Data

- NOAA Environmental Buoys Meteorological Data
 - Hourly wind direction and speed
- USGS River Gage Data
 - Daily river discharge
- TRMM
 - Daily total precipitation
- LandSat
 - IDRISI Land Change Modeler
- Water Quality
 - *E. Coli*
 - Total coliforms

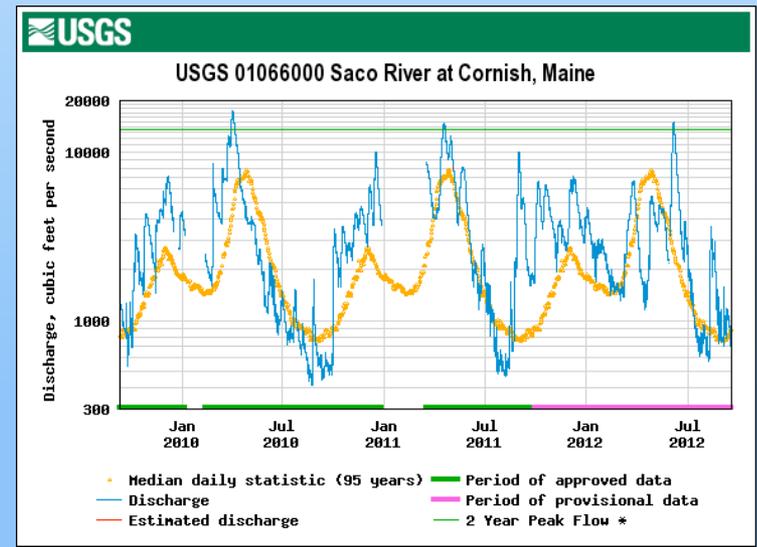
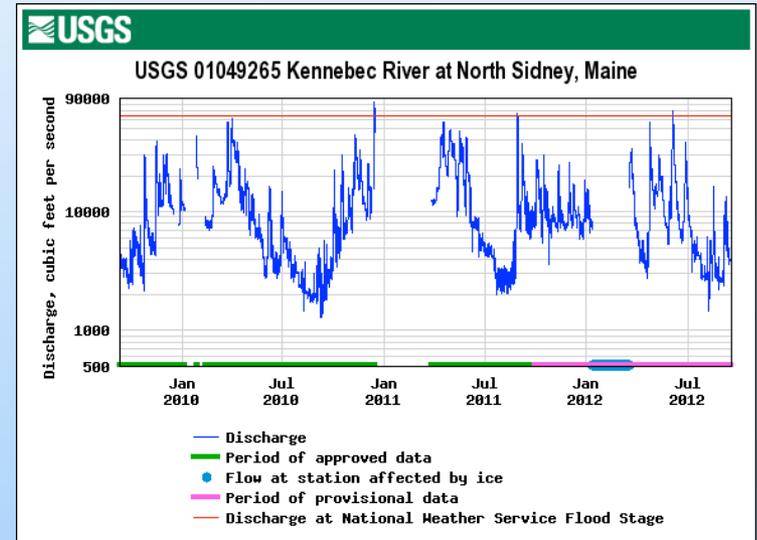
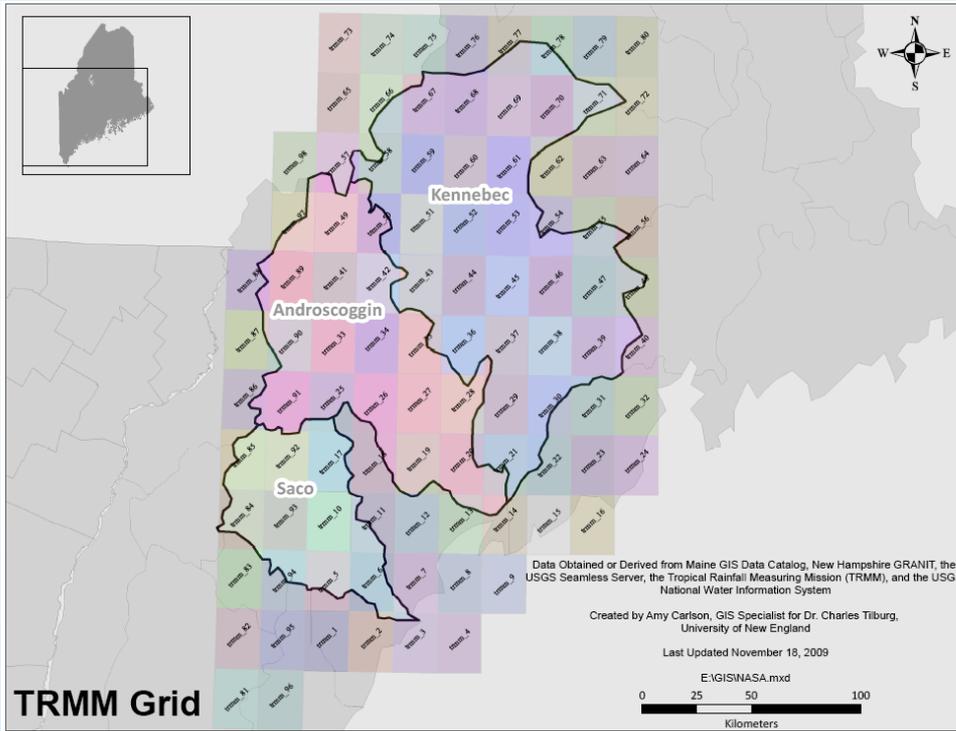
Study Tasks:

- 1) Determine landuse characteristics of regions
- 2) Determine river discharge and precipitation
- 3) Obtain water quality measurements
- 4) Predict RWQEs using precipitation
- 5) Use regression analysis to predict water quality
- 6) Use newfound knowledge to predict future water quality

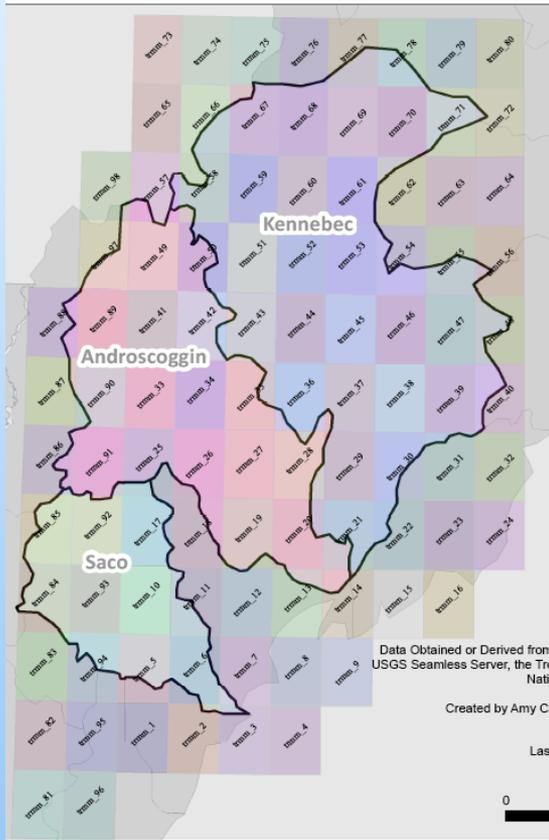
Task 1: Determine land use characteristics in region



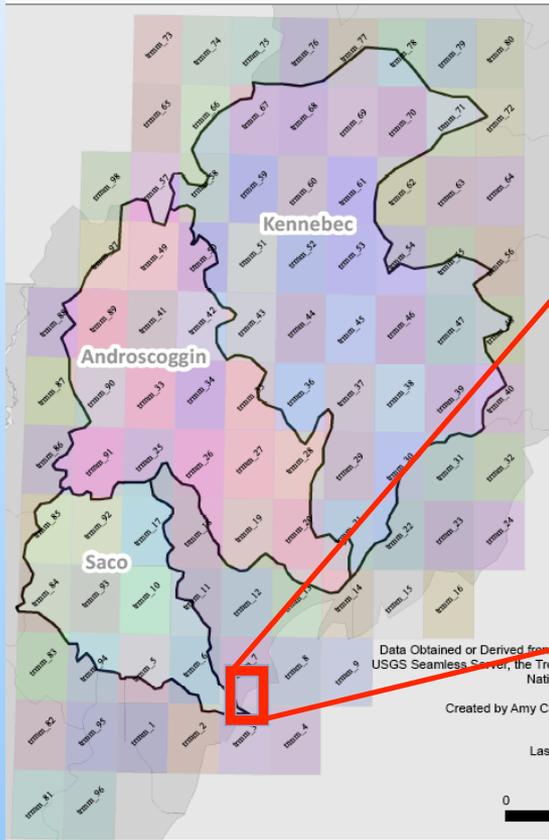
Task 2: Determine River Discharge and Precipitation



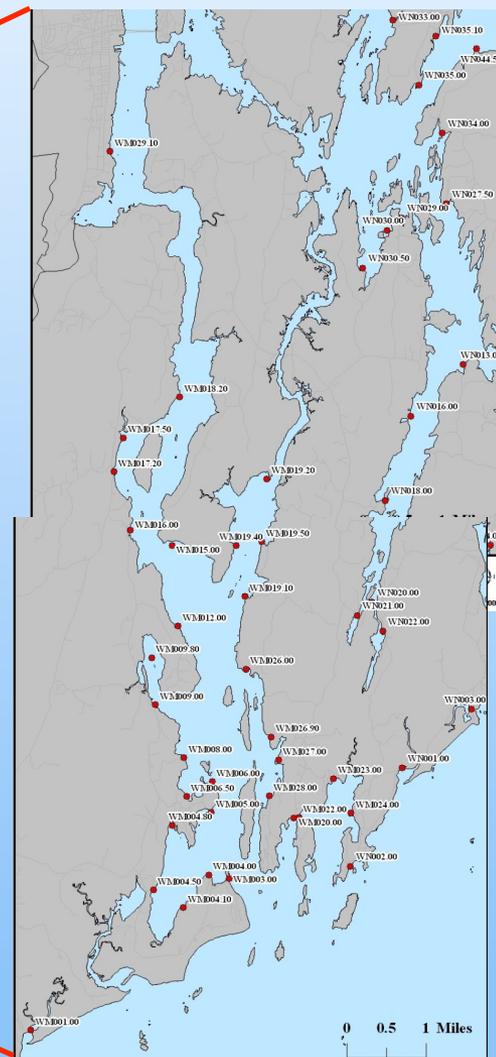
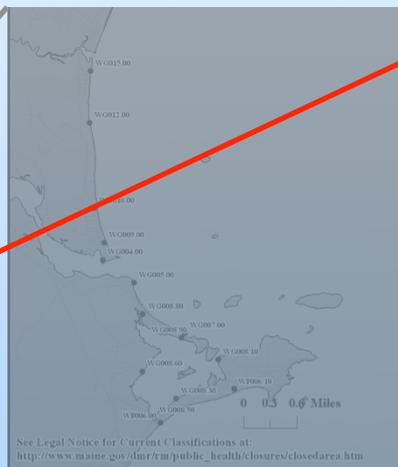
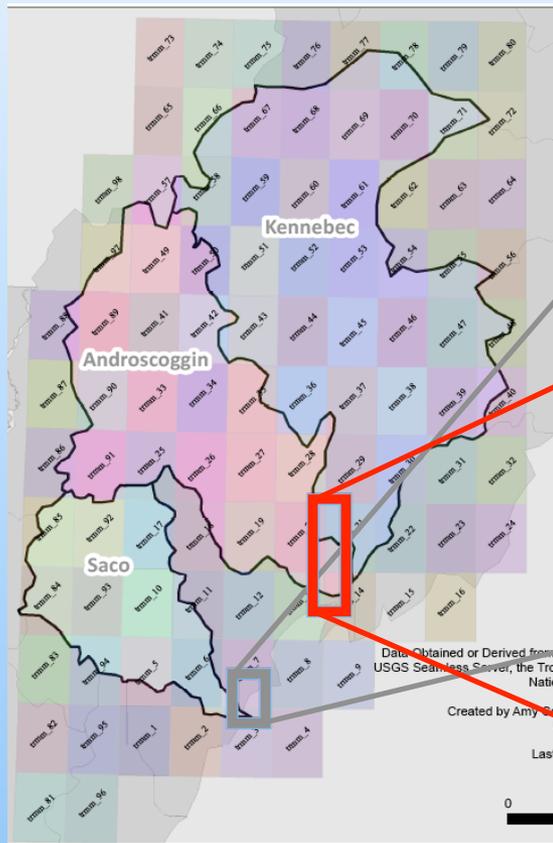
Task 3: Obtain Water Quality Measurements



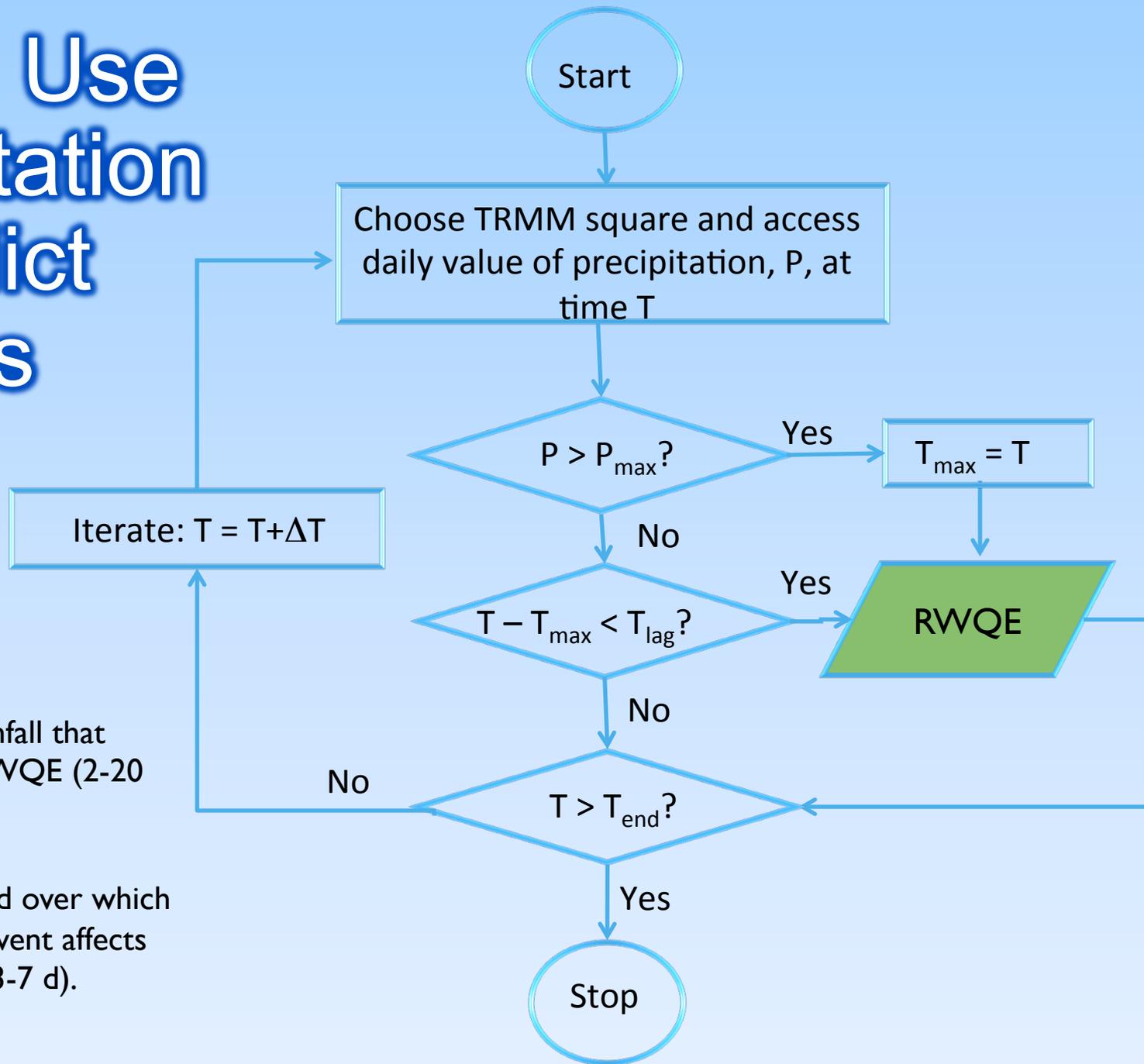
Task 3: Obtain Water Quality Measurements



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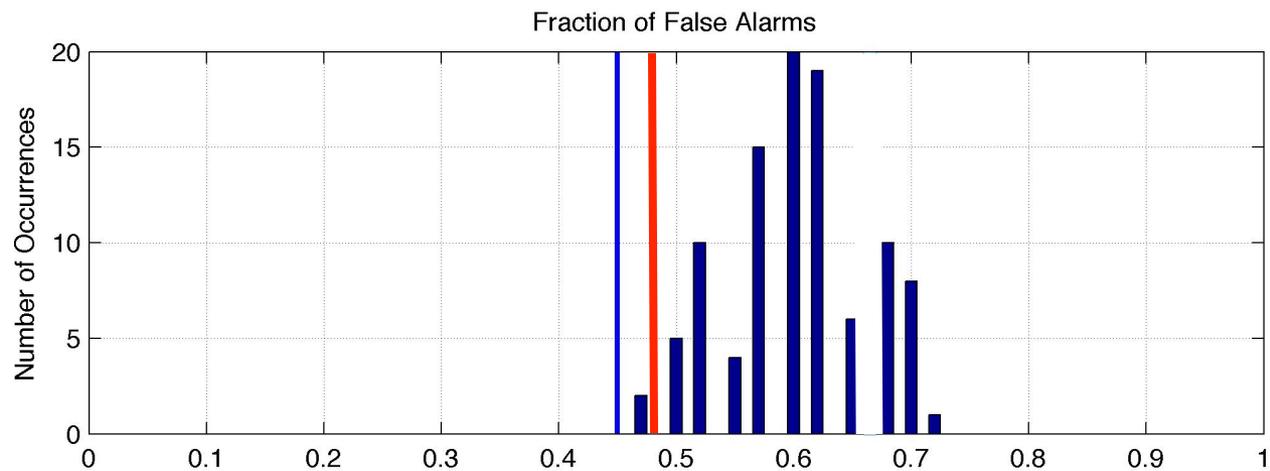
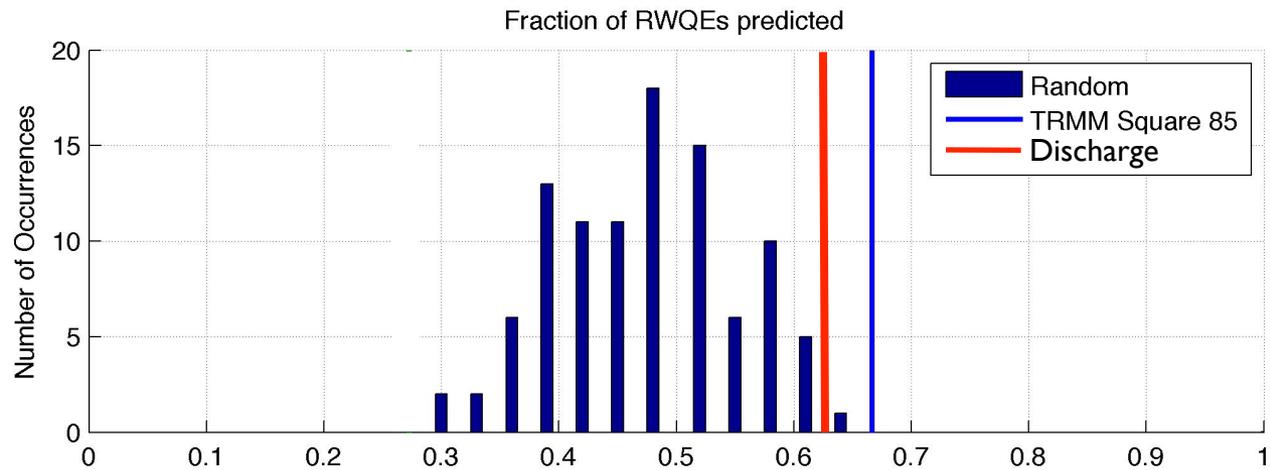
Task 4: Use Precipitation to Predict RWQEs



P_{max} = amount of rainfall that produces a RWQE (2-20 mm/d).

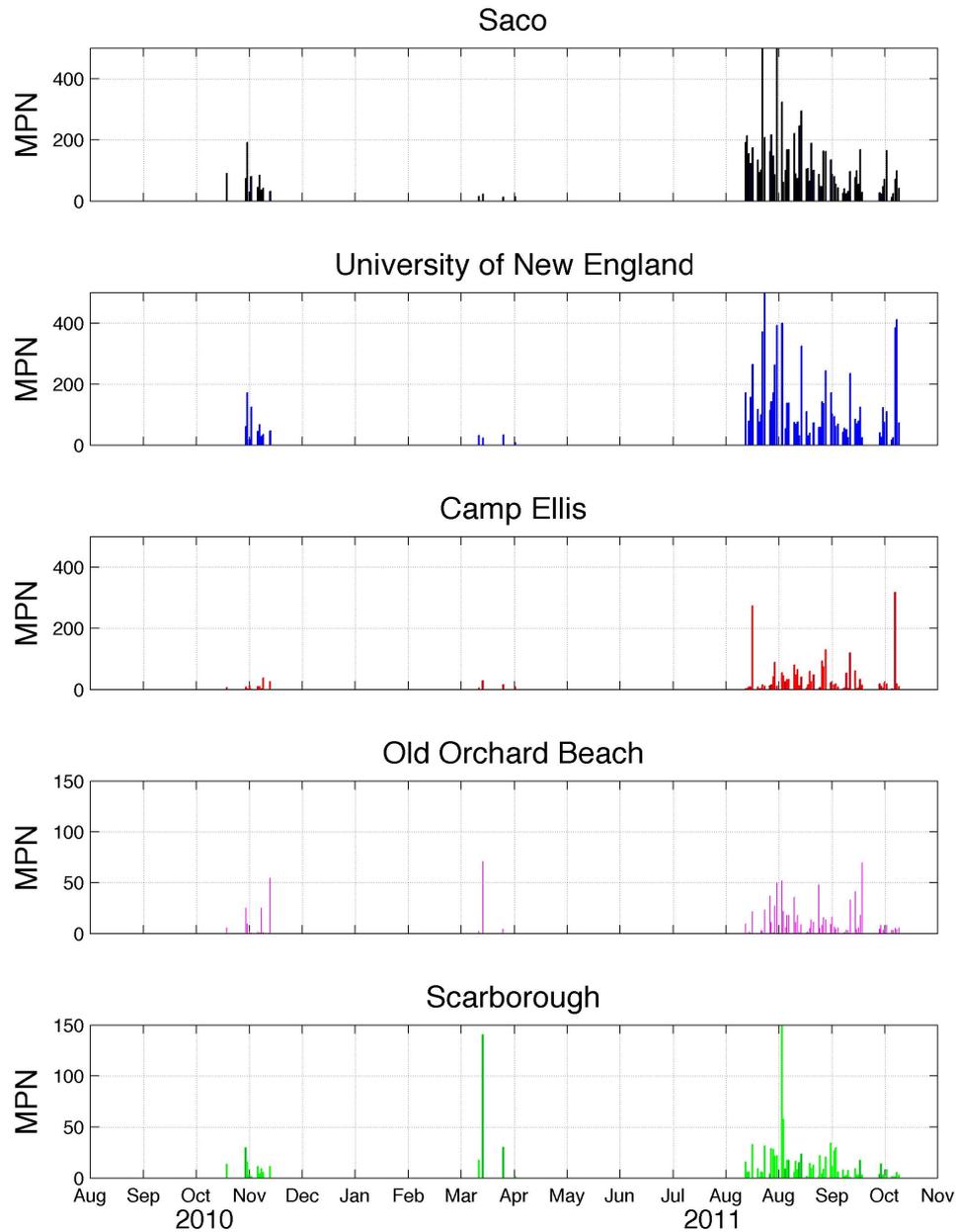
T_{lag} = the time period over which precipitation event affects region (range 3-7 d).

New method outperforms current method

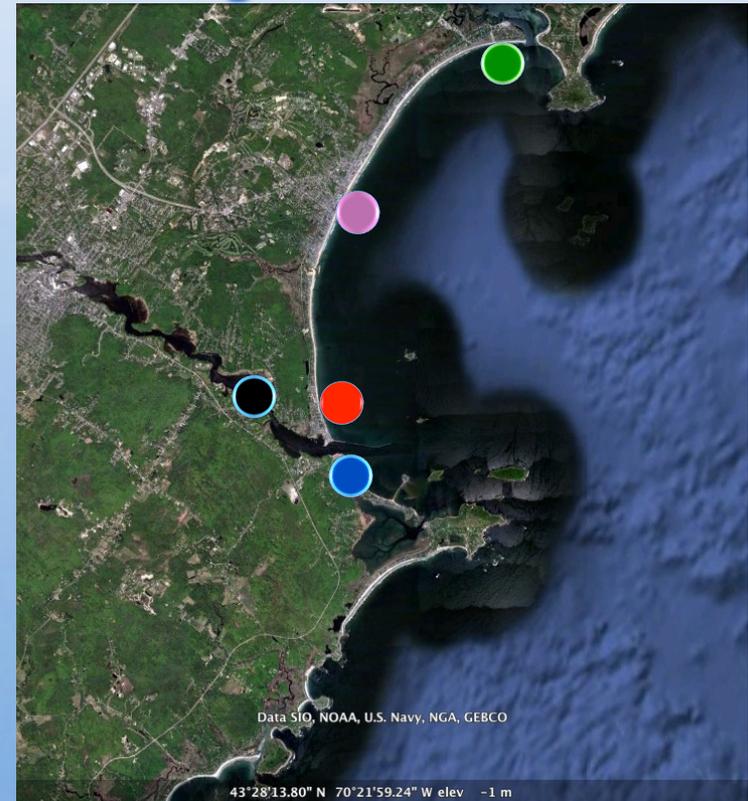


The use of TRMM data works!

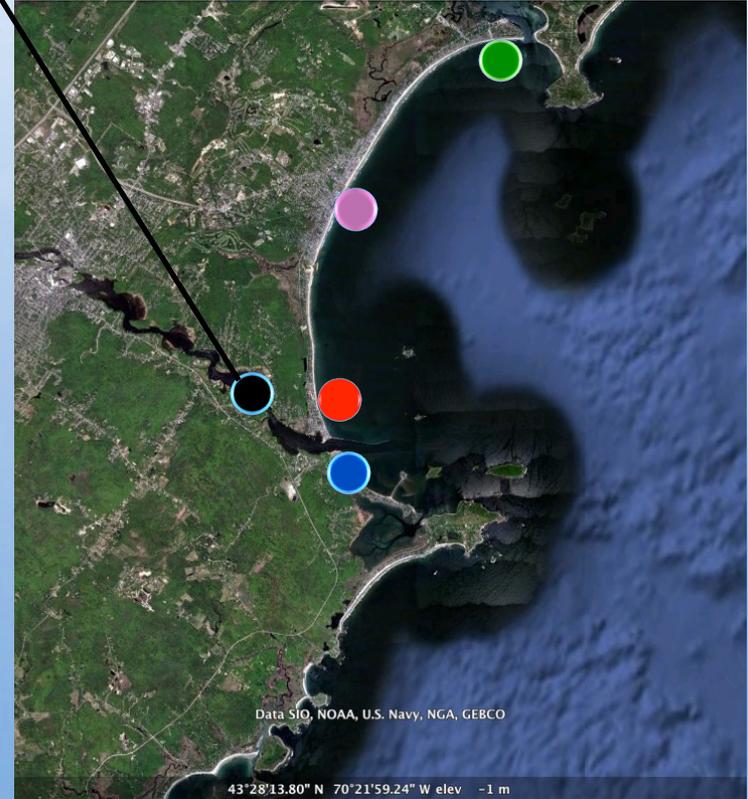
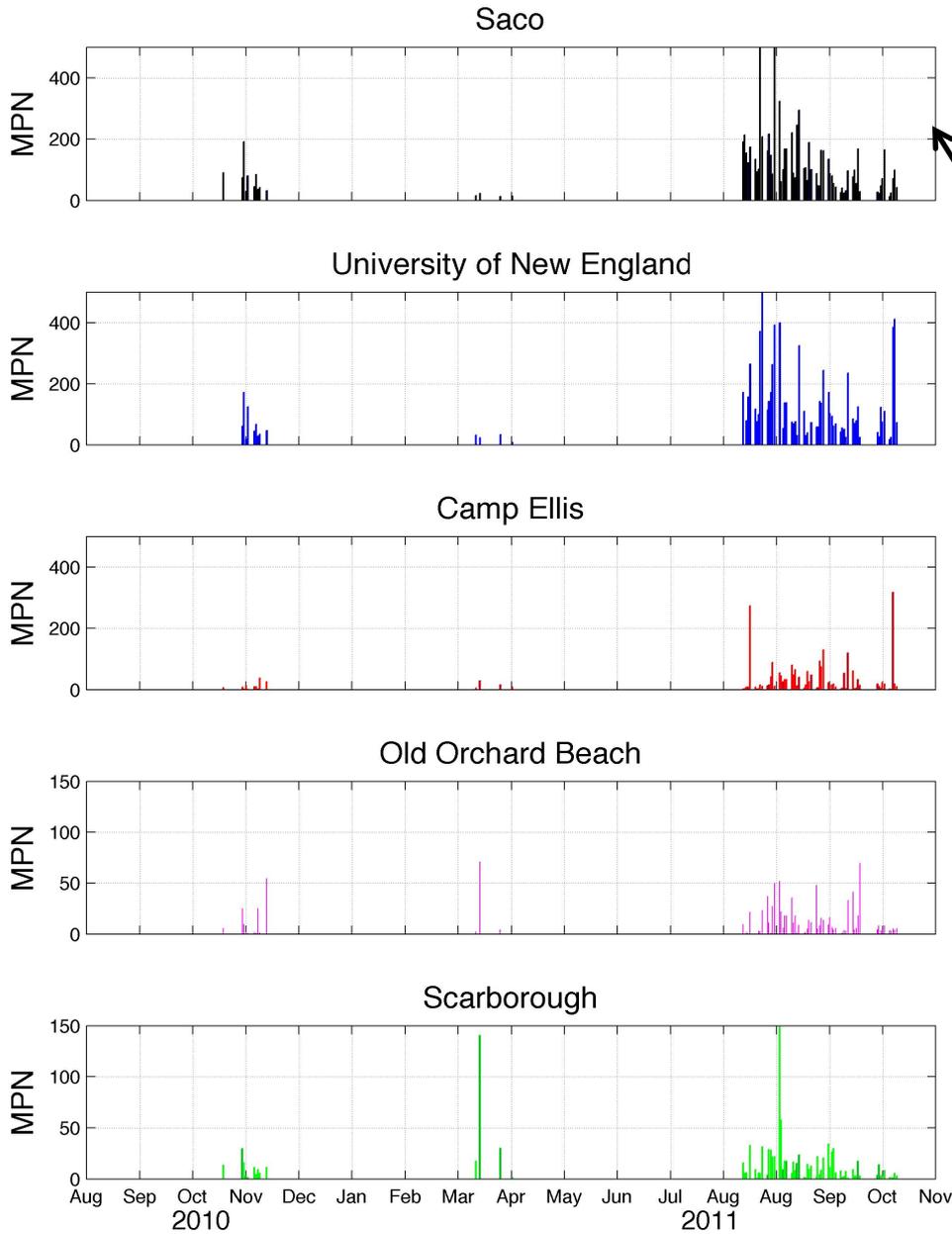
- Near-real time satellite data is a statistically better predictor of contaminant levels
- Data are rapidly available and are cost effective for managers
- But we needed more continuous data

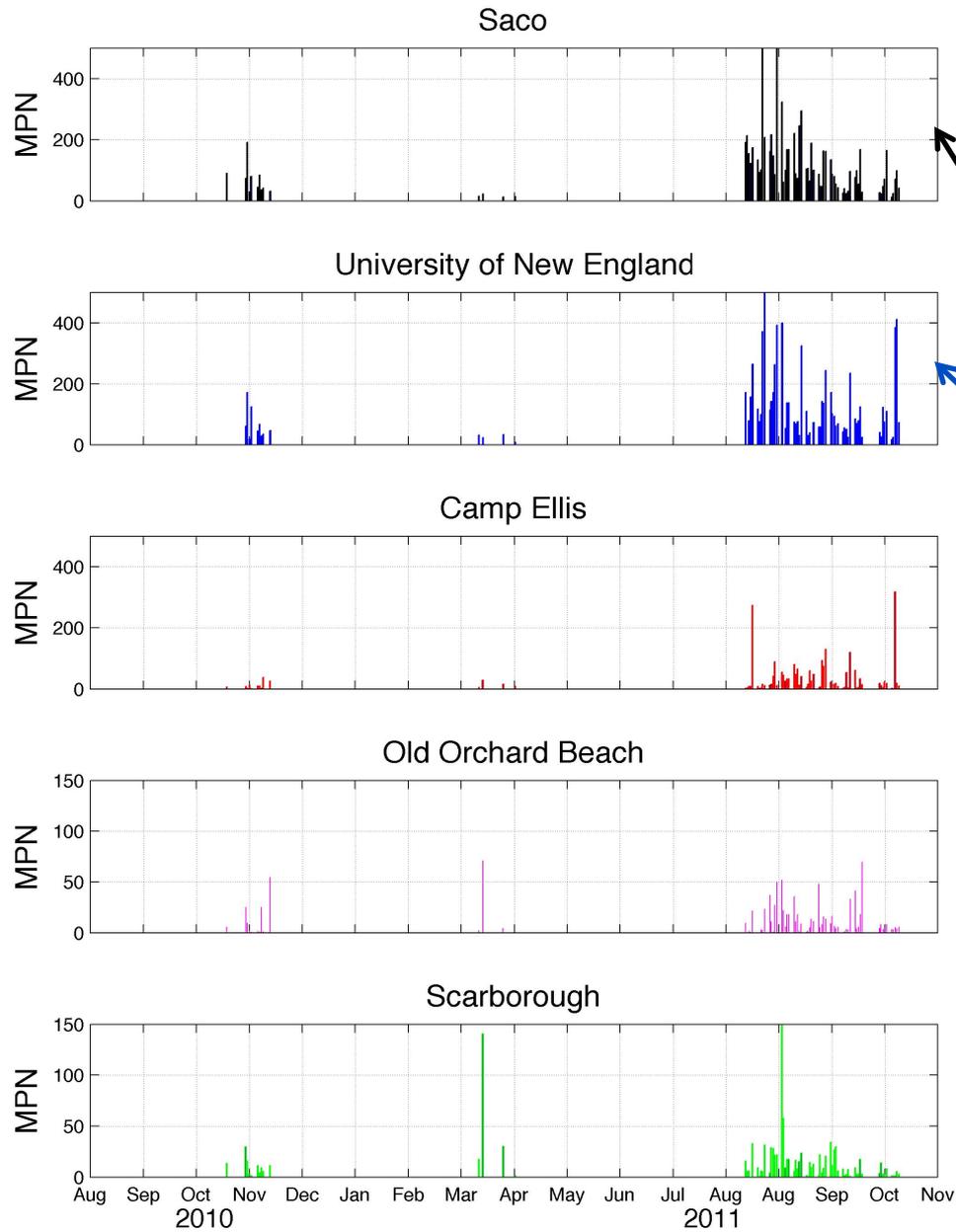


Task 5: Use Regression Analysis to Predict Water Quality

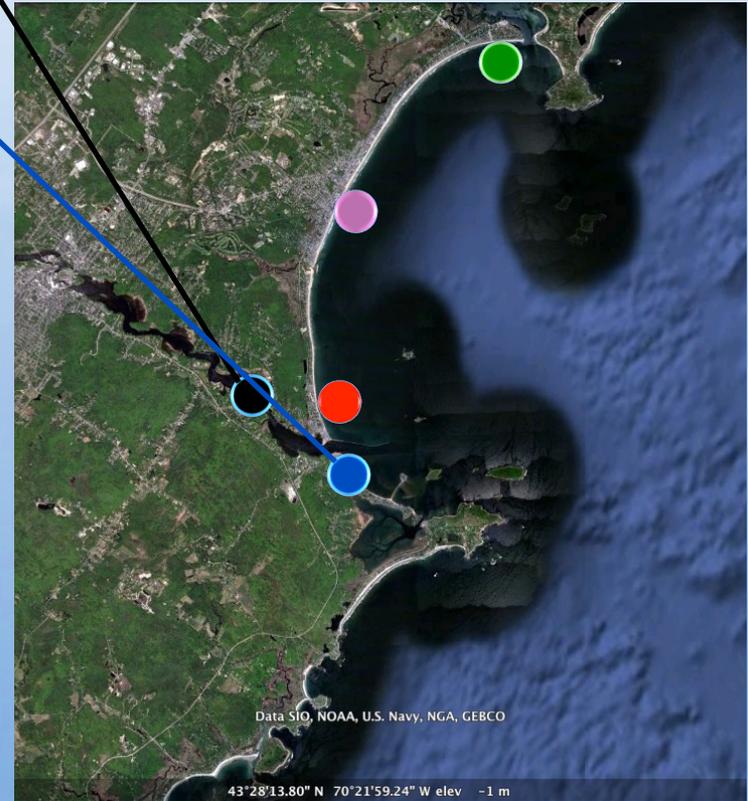


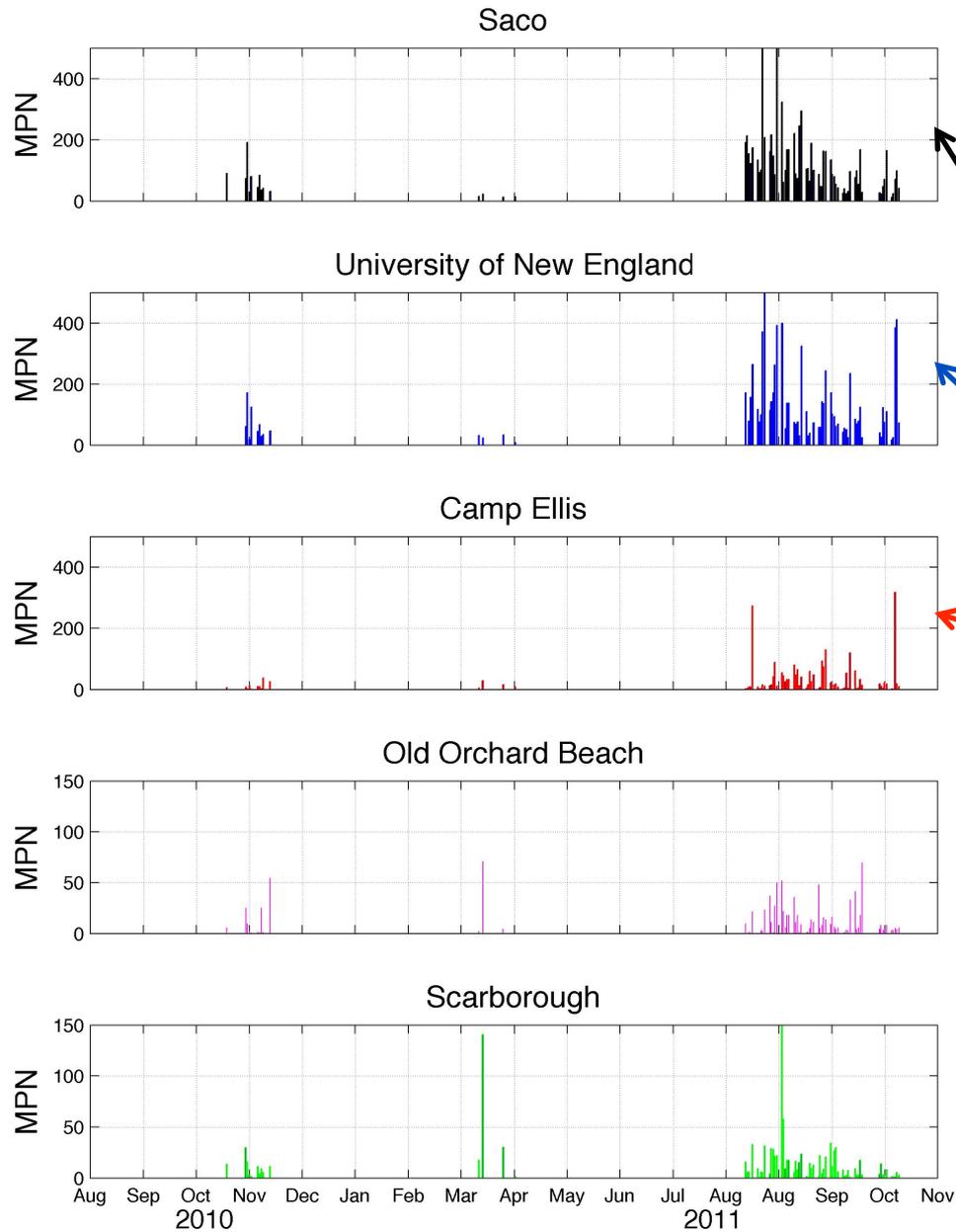
Task 5: Use Regression Analysis to Predict Water Quality



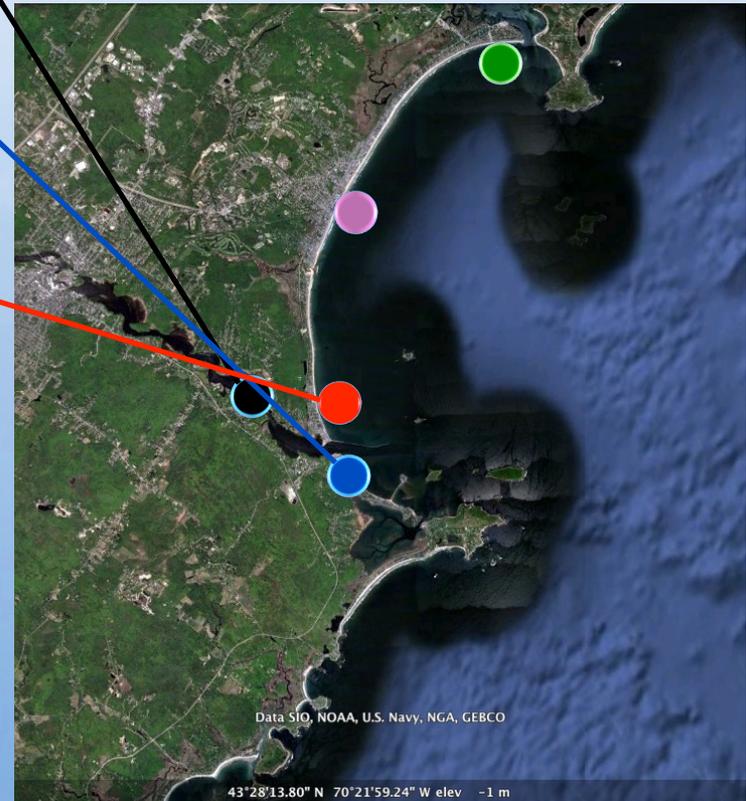


E. Coli samples displayed strong variability.

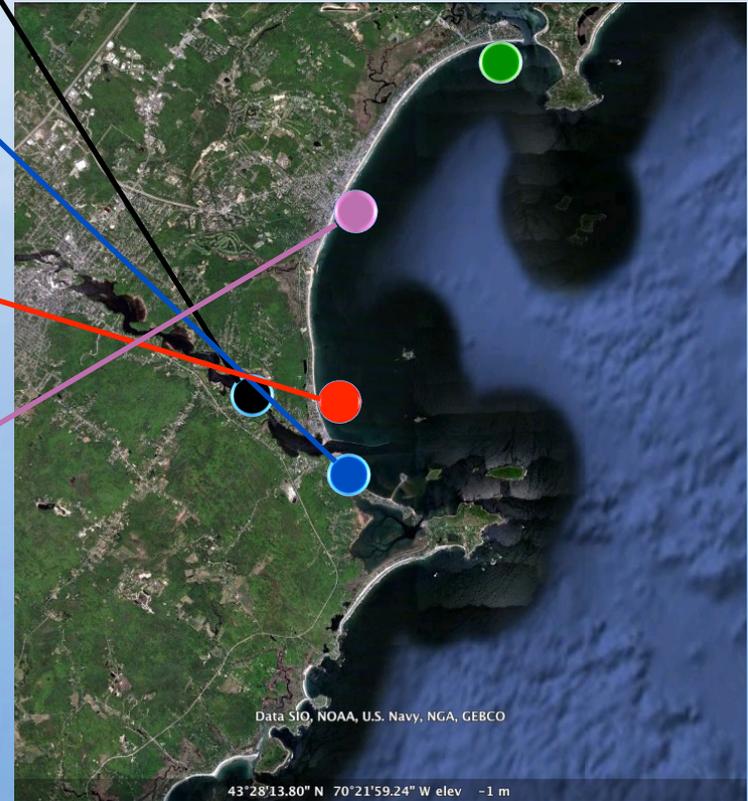
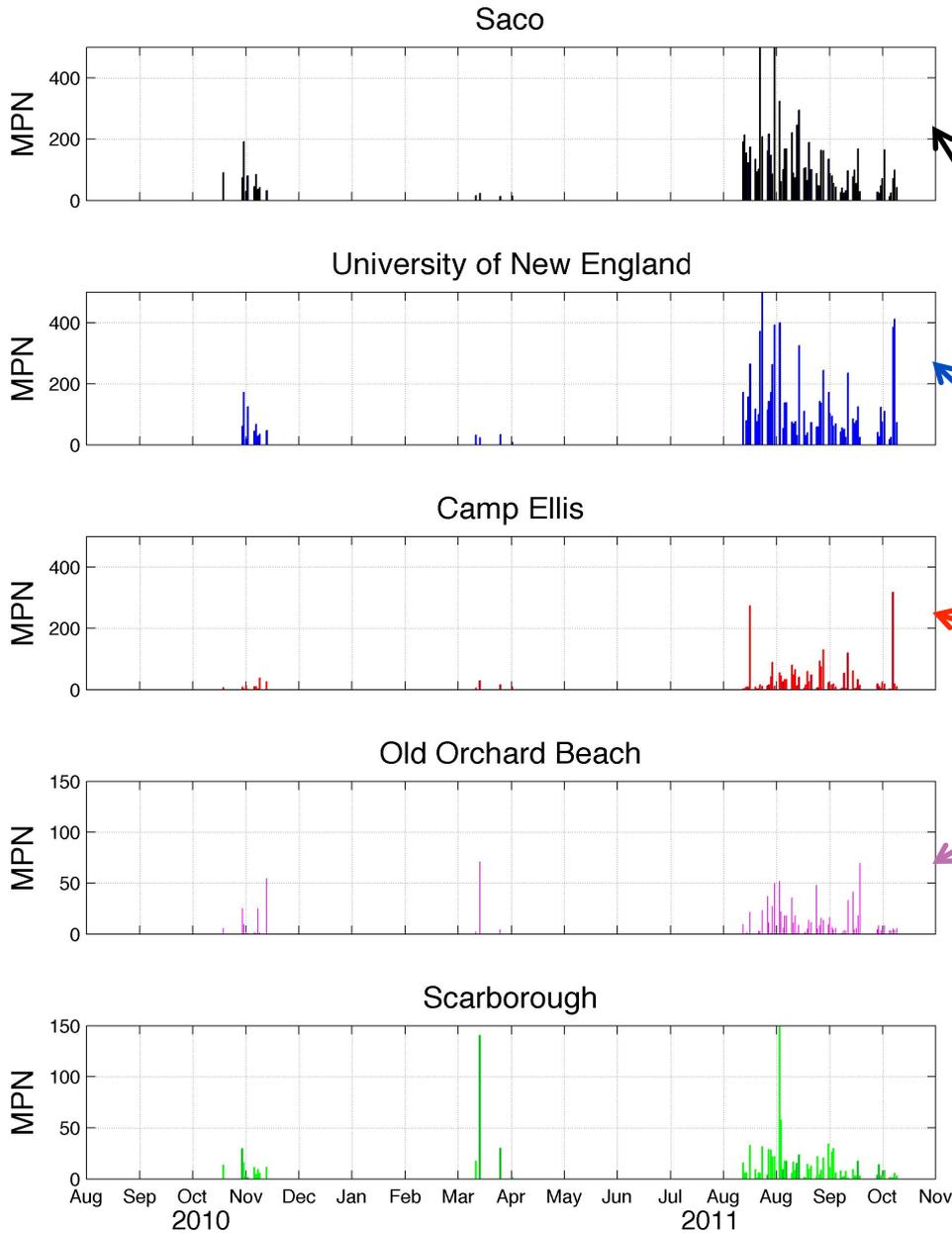




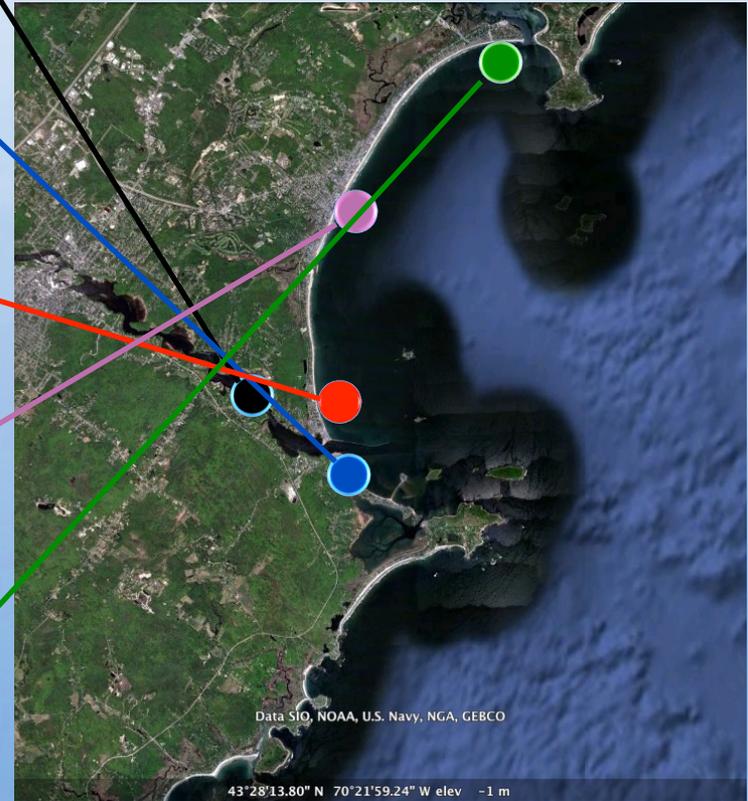
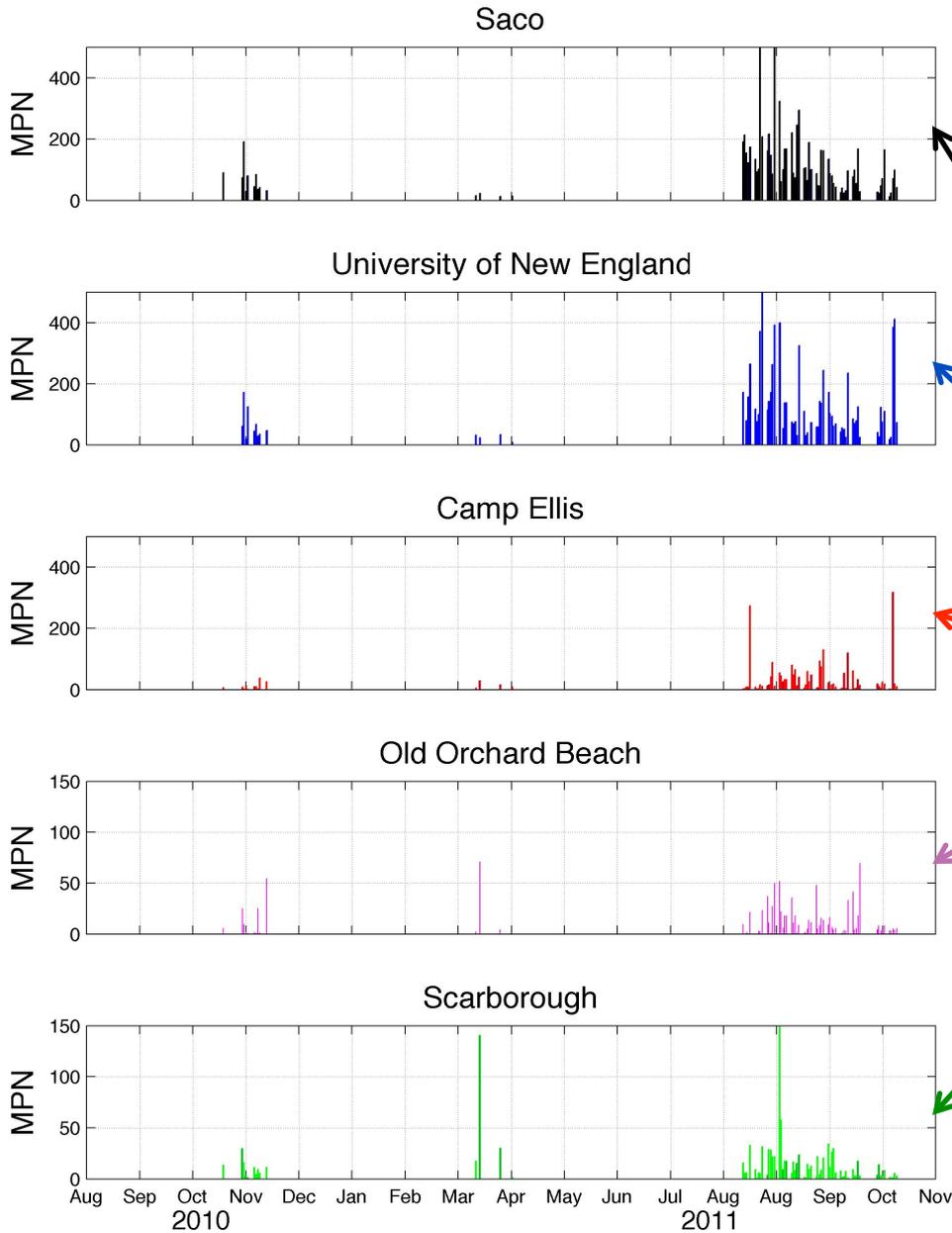
E. Coli samples displayed strong variability.



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E. Coli samples displayed strong variability.



Inclusion of other parameters improves model.

	Discharge	Winds	Sea Level	Salinity	Precipitation	Total
Saco	-0.32	0.34	0.12	-0.23	0.41	0.69
UNE	-0.32	0.34	0.14	0.07	0.21	0.63
C. Ellis	0.19	0.06	0.09	-0.17	0.46	0.60
OOB	-0.38	0.26	0.23	-0.19	0.44	0.66
Scar	0.20	0.52	0.01	-0.28	0.81	0.85

$$W(t) = \sum_{j=1}^M b_j P_j(t - \xi_j)$$

W = water quality

P = physical parameter

b = weighting function

ξ = time lag

j = counter

Conclusions

- The use of satellite derived precipitation data was successful in forecasting water quality in the coastal waters of Maine.
- The combination of TRMM data, wind, discharge, and salinity data can predict water quality at small (~ 5 km) spatial scales in the coastal region.
- The simple model can be expanded to larger coastal regions.

Issues

- ▣ Coastal water quality is dependent on non-physical factors not easily parameterized.
- ▣ Link between land use and water quality at desired spatial scales is tenuous
- ▣ Downscaled precipitation data cannot predict RWQEs

Effects on Maine Communities

- Provided alternative method for Maine State Planning Office and Maine Department of Marine Resources to use in prediction of RWQEs
- Provided stipends and projects for
 - 5 undergraduate students
 - 2 graduate students
- Provided data for outreach to 7 local schools

What's next?

- \$91,245 has been spent as of 09/15/2012
 - Remaining \$4125 will be spent by 10/01/2012
- Submit two manuscripts to peer-reviewed journals by May 2013
- Use new model to predict RWQEs in Saco region
- Investigate link between land use and water quality.
- Investigate effects of climate change on precipitation and water quality



Thank you!